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GoFFish : A Sub-Graph Centric Framework for Large-Scale Graph Analytics

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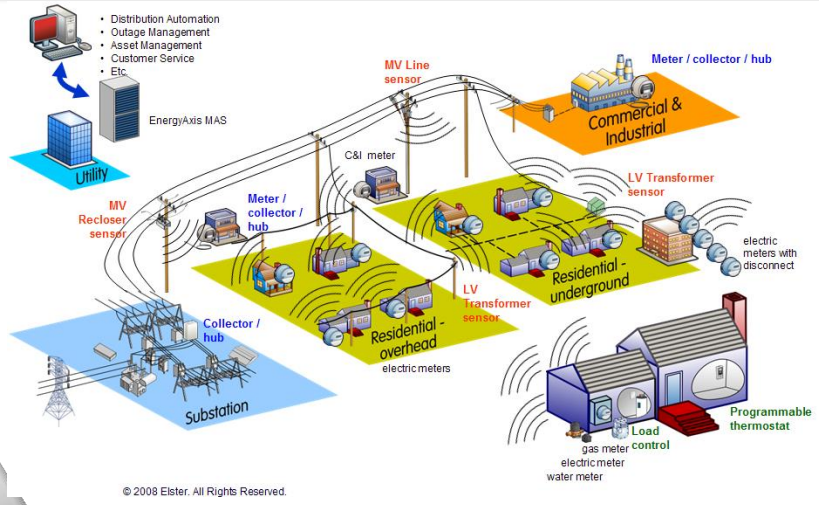
Big Data



Twitter Storm

Pregel

Map Reduce

1st Mentioning of Big Data

Michael Cox and David Ellsworth publish "Application-controlled demand paging for out-of-core visualization" in the Proceedings of the IEEE 8th conference on Visualization, 1997

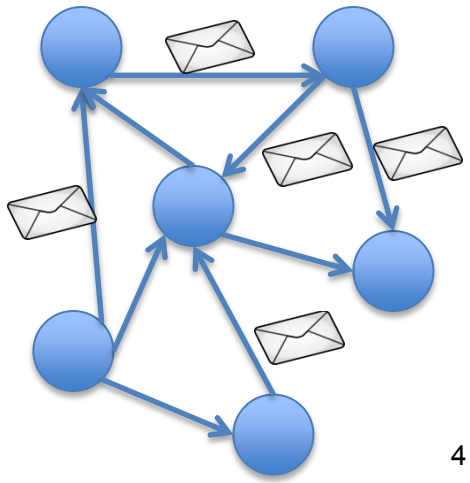
http://www.gartner.com/it-glossary/big-data/

GoFFish Overview

- Scalable platform for ***large scale graph analytics*** in commodity clusters and cloud.
- Simple yet scalable programming abstraction for large scale graph processing
- More than **10x improvements** in some graph algorithms over traditional graph processing systems
- Components
  - **GoFS** : Sub-graph centric ***Distributed Graph Storage***
  - **Gopher** : Distributed ***BSP-based programming abstraction*** for Large Scale graph analytics framework

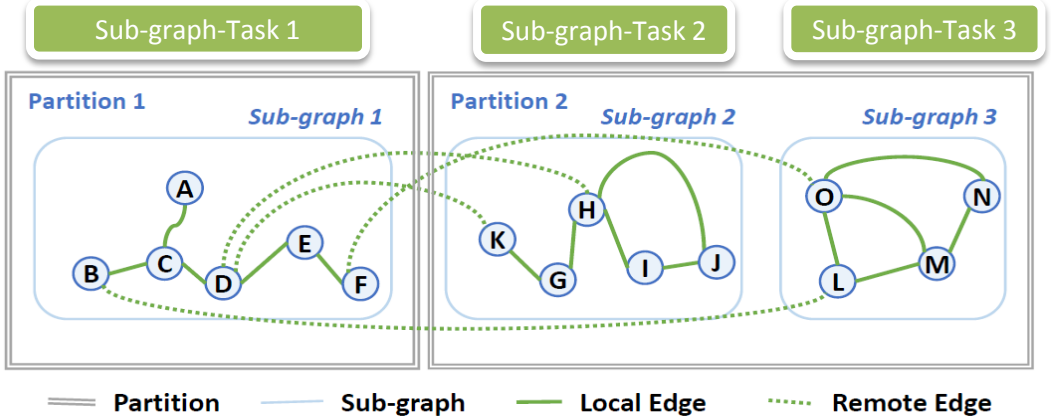
Vertex centric programming model

- Iterative vertex centric programming model based on Bulk synchronous parallel model.
- In each iteration vertex can
  1. Receive messages sent to it in previous iteration
  2. Send messages to other vertices
  3. Modify its own state
- Vertex centric programming mode- ***Think like a vertex***
- Very simple,
- High communication overhead
- Pregel, http://giraph.apache.org/



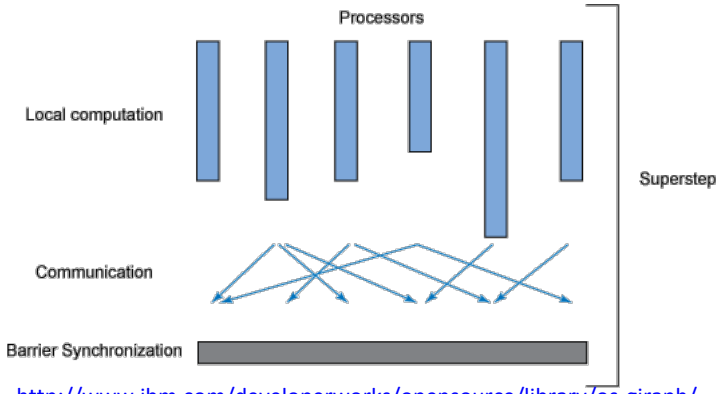
Subgraph Centric Programming Model

- Partition graph in to set of sets of vertices and edges
- ***Sub-graphs*** – Connected components in a partition.
- User logic operates on a sub graph
  - Independent unit of computation
- Resource allocation
  - Single Partition → Single Machine | Single Sub-graph → Single CPU
- Data loading
  - Entire partition is loaded into memory before computation
  - Tasks retain sub-graphs in memory within the task scope

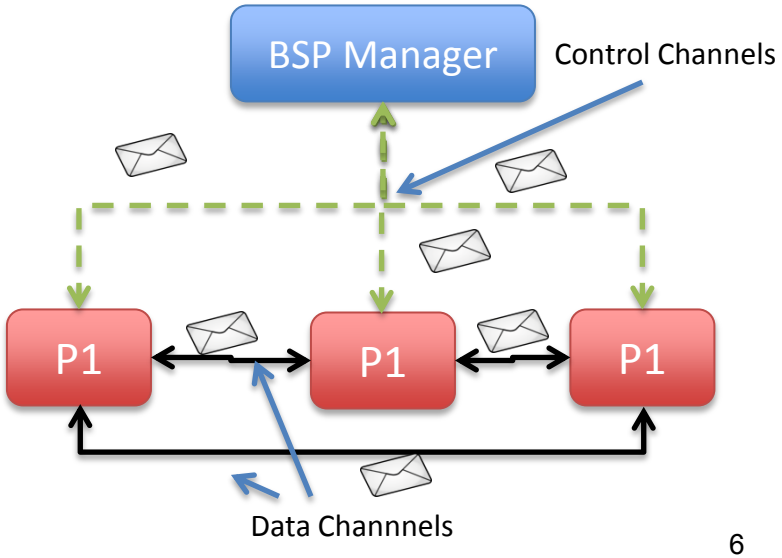


Sub-graph Centric Programming Model

- **Algorithm** : Seq^n of super-steps separated by global barrier synchronization
- Super Step i:
  1. Sub-graphs compute in parallel
  2. Receive messages sent to it in super step i-1
  3. Execute same user defined function
  4. Send messages to other sub graphs (to be received in super step i+1)
  5. Can vote to halt : I'm done / de-activate
- Global ***Vote to Halt*** check
  - termination → all sub-graphs voted to halt
- Active sub graphs participate in every computation
- De-activated sub-graphs will not get executed/activated unless it get new messages



http://www.ibm.com/developerworks/opensource/library/os-giraph/

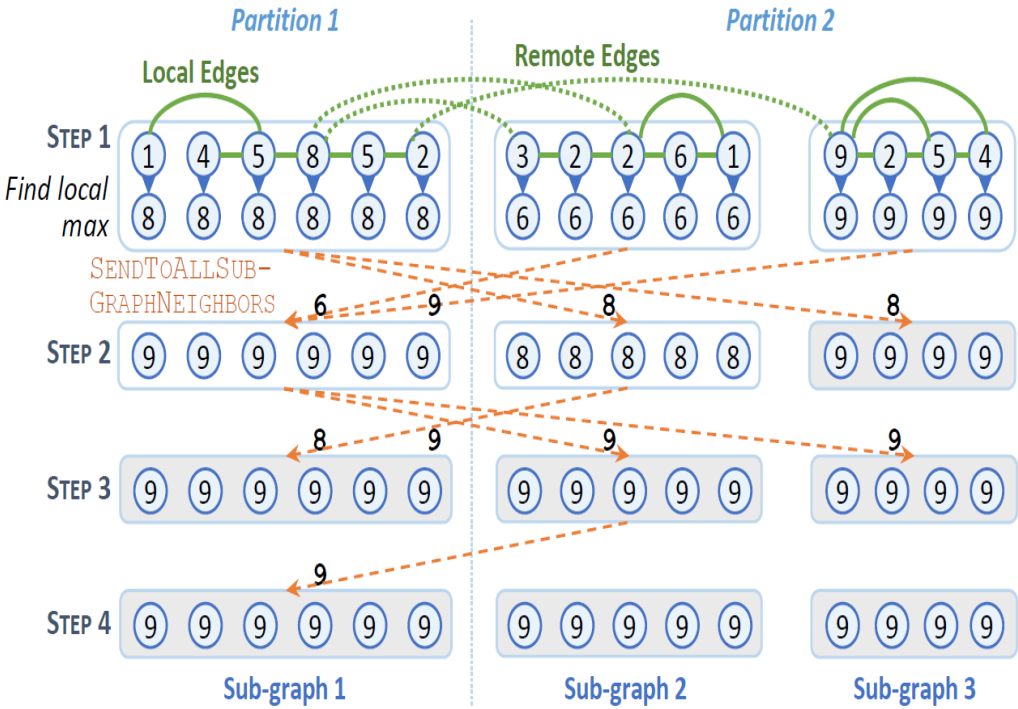


Sub-graph Centric Programming Model Example

- **Algorithm** – Max vertex value
- **Input** – Connected graph with different vertex values $\{n_1, n_2 \ldots n_i\}$
- **Output** – Each vertex with the Max ($\{n_1, n_2 \ldots n_i\}$)

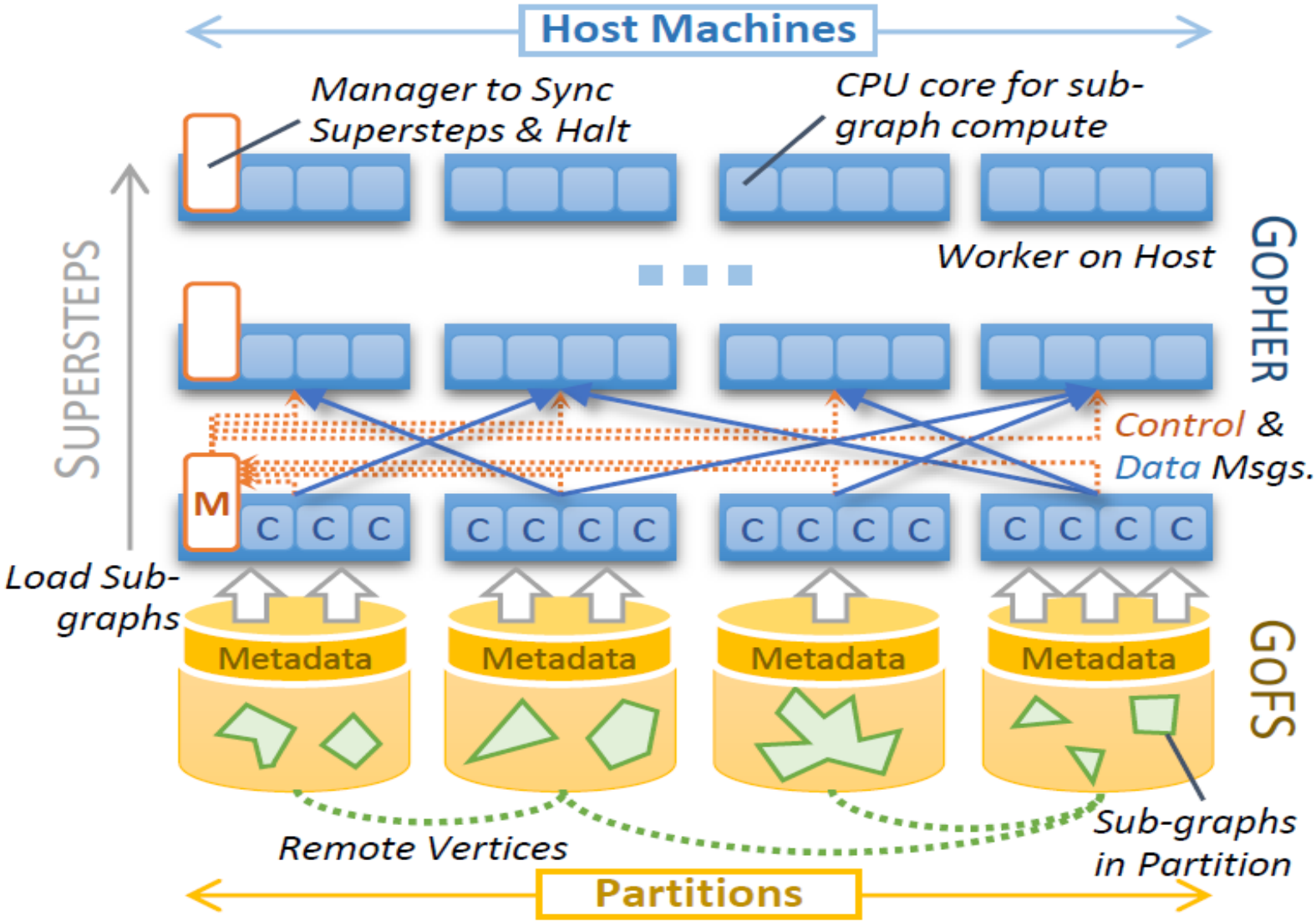
Algorithm 1 Max Vertex using Vertex Centric Model

```
1:  procedure COMPUTE(Vertex myVertex, Iterator⟨Message⟩ M)
2:      hasChanged = (superstep == 1) ? true : false
3:      while M.hasNext do            ▶ Update to max message value
4:          Message m ← M.next
5:          if m.value > myVertex.value then
6:              myVertex.value ← m.value
7:              hasChanged = true
8:      if hasChanged then            ▶ Send message to neighbors
9:          SENDTOALLNEIGHBORS(myVertex.value)
10:     else
11:         VOTETOHALT( )
```



- Compared to Vertex centric model
  - Less communication
  - Fast convergence

Goffish Architecture



Performance Comparisons – Experimental Setup

- Cluster
  - 12 Nodes, 8-Core Intel Xeon CPU (each)
  - 16GB RAM (each), 1TB HDD (each)
- Network
  - Gigabit Ethernet
- Apache Giraph latest version from trunk
  - Includes Performance improvements from Facebook !

Data Set	Vertices	Edges	Diameter
RN: California Road Network	1,965,206	2,766,607	849
TR: Internet path graph from Tracesroutes	19,442,778	22,782,842	25
LJ: LiveJournal Social Network	4,847,571	68,475,391	10

Runtime Performance Comparison with Vertex Centric Model

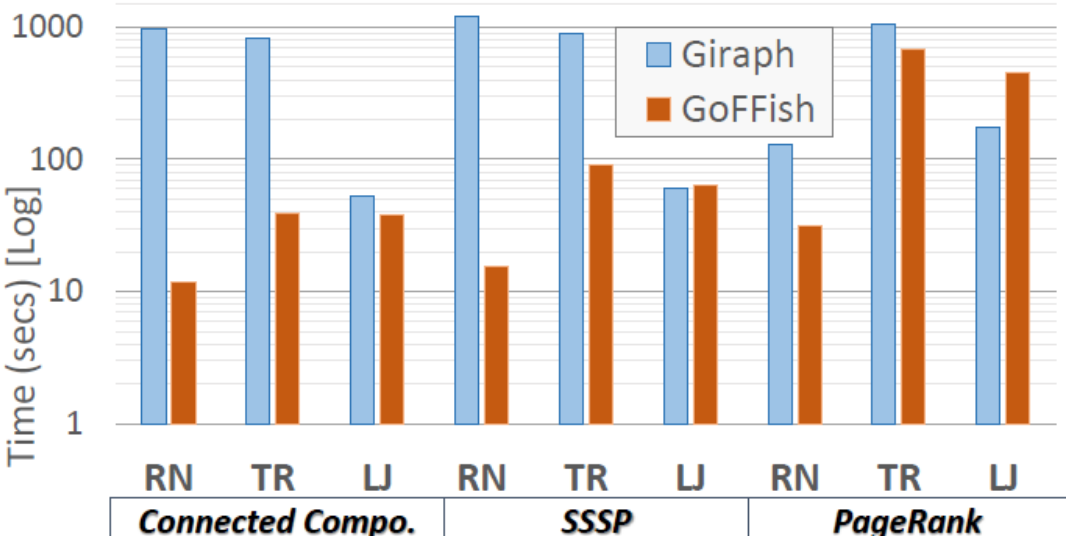
- Connected components
  - 81x improvement using California Road Network (RN) dataset
  - 21x improvement using a Trace route path network of a CDN. (TR) dataset
- Single Source Shortest Path
  - 32x improvement using RN dataset
  - 10x improvement using TR dataset

Page Rank

4x improvement using RN dataset

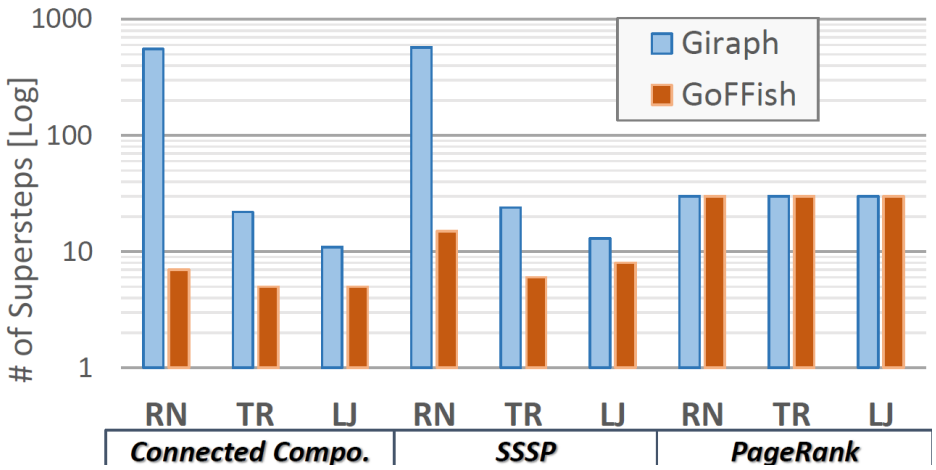
1.5x improvement using TR dataset

Not an ideal algorithm for sub-graph centric programming model



Super Step Reduction Comparison with Vertex Centric Model

- Connected components
  - ~79x reduction using RN dataset.
  - ~4x reduction using TR dataset
  - ~2x reduction using Live Journal dataset (LJ)
- Single source shortest path
  - ~38x reduction using RN data set
  - 4x reduction using TR dataset
  - ~1.6x reduction using Live journal dataset



Conclusion

- Introduced a ***sub-graph centric programming abstraction*** for large scale graph analytics on distributed systems
  - Simple
  - Enable using shared memory algorithms at sub-graph level.
- ***Sub-graph centric algorithms*** and performance results
  - Connected Components
  - Single Source Shortest Path
  - Page Rank
- Issues and Future work
  - Sub-graph aware partitioning
  - Sub-graph centric algorithms
- Try now
  - https://github.com/usc-cloud/goffish

Thank you!

http://thesciencepresenter.wordpress.com/category/behaviour-management/